

IEEE Consumer Electronics Society

Atari 800 series computers: 40 years

Encore: Atari's Second System



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UW Engineering faculty

Agenda

- How I got here
- What we learned
- What we wanted
- What we designed: hardware and software
- What happened in the market and industry
- What we learned
- Where are we now
- Design credits
- Resources

How I got here: three generations of animation machines

Animation Machines:



On display at Living Computer Museum
& Computer History Museum

First Video Games

- Ralph Baer was a pioneer
- He recognized that it was possible to bring entertainment home.
- He imagined a machine which allowed electronic gaming on a “Brown Box” in a family home.
- Ralph was unlucky – he worked in defense
- His employer licensed his design to Magnavox – as the Odyssey, 1972



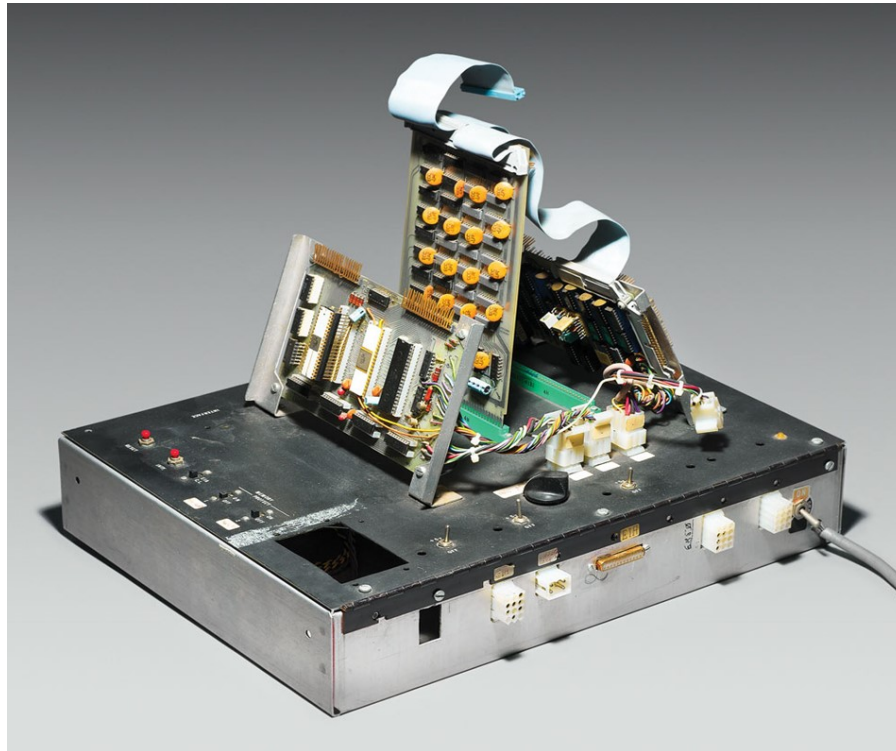
Ralph Baer
in his basement
lab, 2014

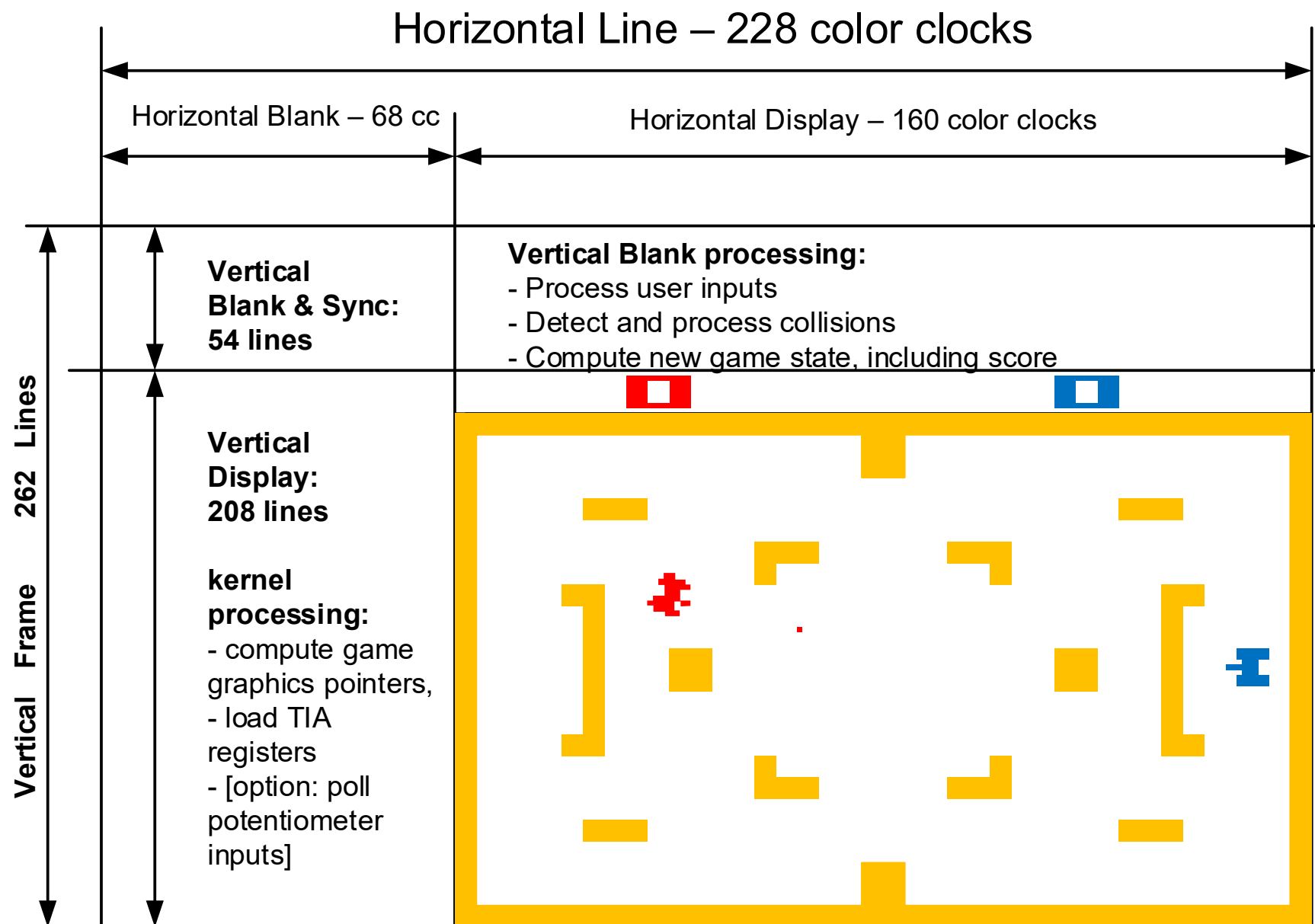
Atari Video Computer concepts

- Atari was founded on arcade video games
- First big hit: Pong (derived from Odyssey)
- Second hits: more complex arcade games
 - E.g. Tank, Breakout
- Third hit: Pong for home use
- Big question: what to do next?
- Choices:
 - Random logic games
 - Microprocessor-based games

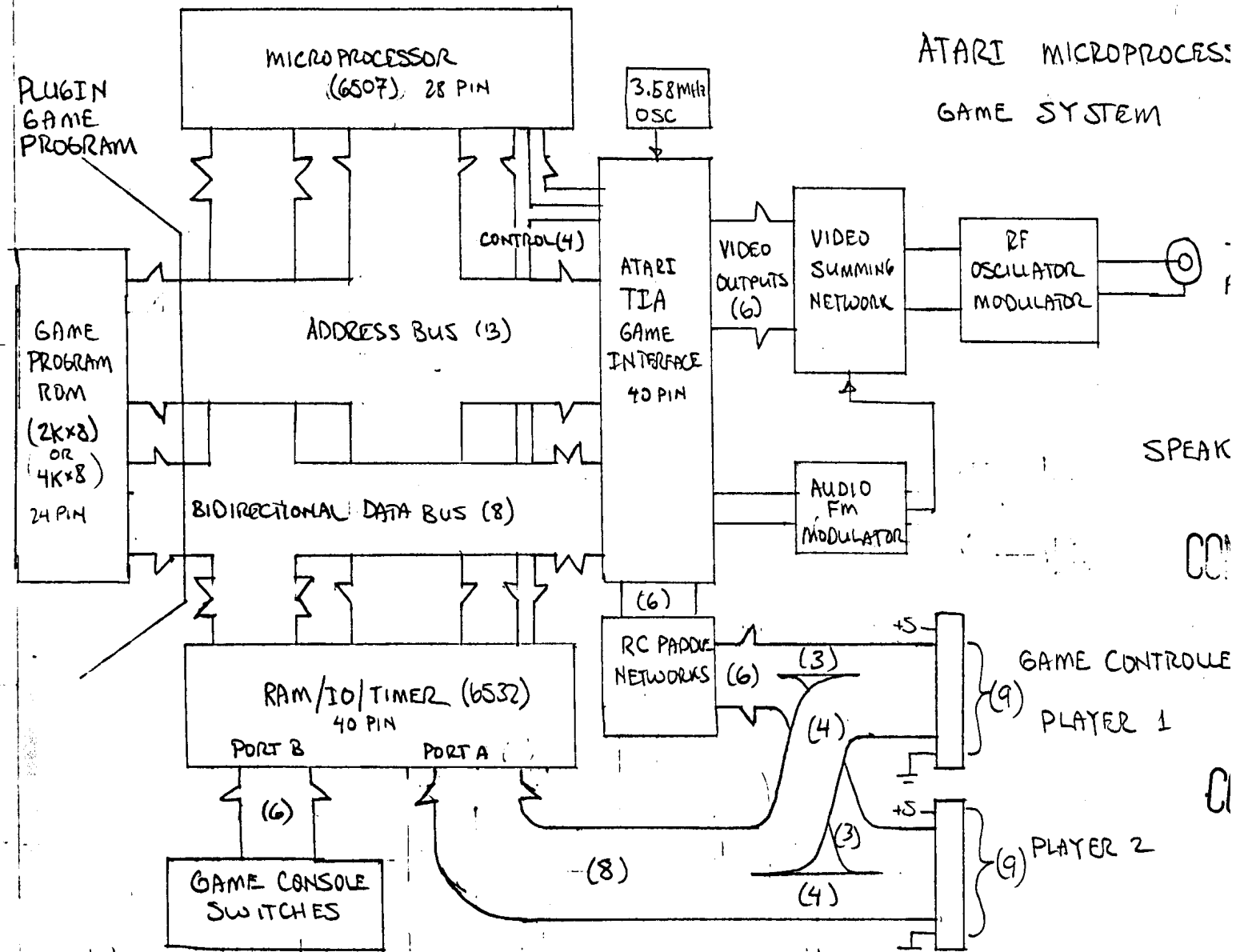
I got lucky: Atari Video Computer

- I was hired to finish debugging the first concept prototype of the Atari Video Computer System, aka Atari 2600
- I made several contributions to it.
 - We used to joke about paying to work on it.





Atari 2600 Program flow



Atari 2600 system diagram



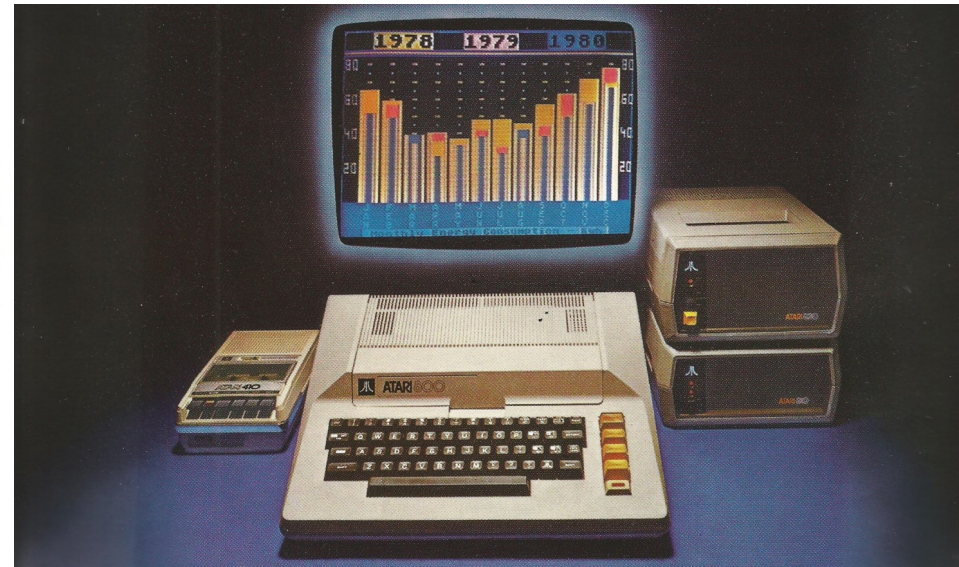
Lessons learned

- We put the definition of the display in the hands of the game designers, who were smarter than we hardware designers expected.
- Our second system should not simply be a bit map and a processor.
- We had created a platform for the art of others, and we planned to build on that for the next system.
- We wanted to make it easy to create new games, including ports of popular arcades games – from Atari and from its competitors.
- We thought we needed to move fast.
- The Atari Personal Computer System (PCS, 800-series) came out two years later, in 1979 – 40 years ago this year.

Atari's Second System

Luckier: I got to do it again

- Continue advancing technology.
- We had a hard decision: is the next machine a better game console (Atari 400), a personal computer (Atari 800), or both?

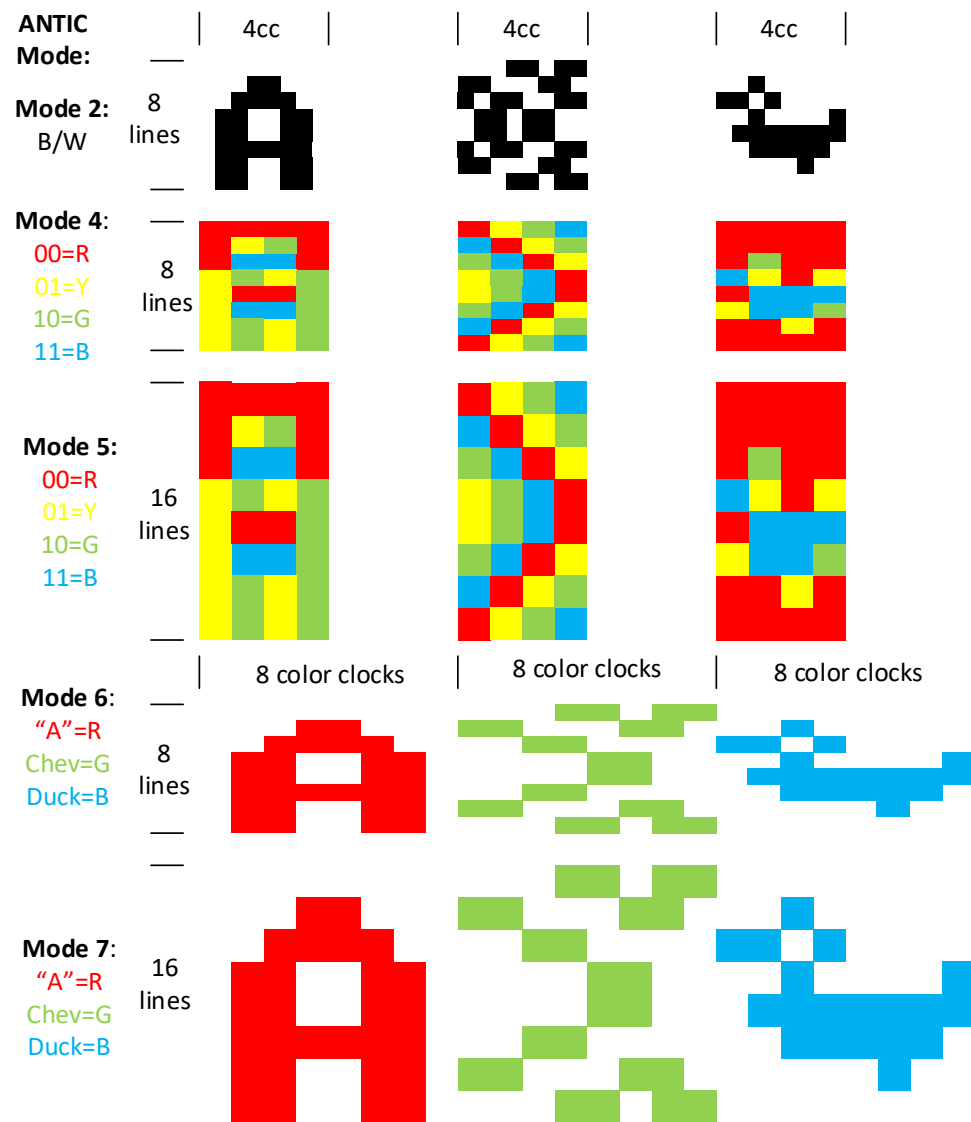


For a better game player

- Support memory-mapped video display
 - We could afford at least 4-8K of DRAM
- Use that memory in various ways:
 - 4-color bit maps up to 160x192 pixels
 - Monochrome up to 320x192 pixels
 - Color and monochrome character modes
- More sprite engines, easy to reuse vertically
- Provisions for vertical and horizontal scrolling
- Add simple video co-processor (display list processor) which can change modes

ANTIC character and graphics modes

ANTIC mode	Resolution H x V	colors	Pixel H size (cc)	Pixel V size (line)	Char H size (cc)	Char V size (line)	Bytes per screen	Char set size (bytes)
2	40 x 24	2	0.5	1	4	8	960	1024
3	40 x 20	2	0.5	1	4	10	800	1024
4	40 x 24	4	1	1	4	8	960	1024
5	40 x 12	4	1	2	4	16	480	1024
6	20 x 24	4	1	1	8	8	480	512
7	20 x 12	4	1	2	8	16	240	512
8	40 x 24	4	4	8	-	-	240	-
9	80 x 48	2	2	4	-	-	480	-
A	80 x 48	4	2	4	-	-	960	-
B	160 x 96	2	1	2	-	-	1920	-
C	160 x 96	4	1	2	-	-	3840	-
D	160 x 192	2	1	1	-	-	3840	-
E	160 x 192	4	1	1	-	-	7680	-
F	320 x 192	2	0.5	1	-	-	7680	-



ANTIC character modes

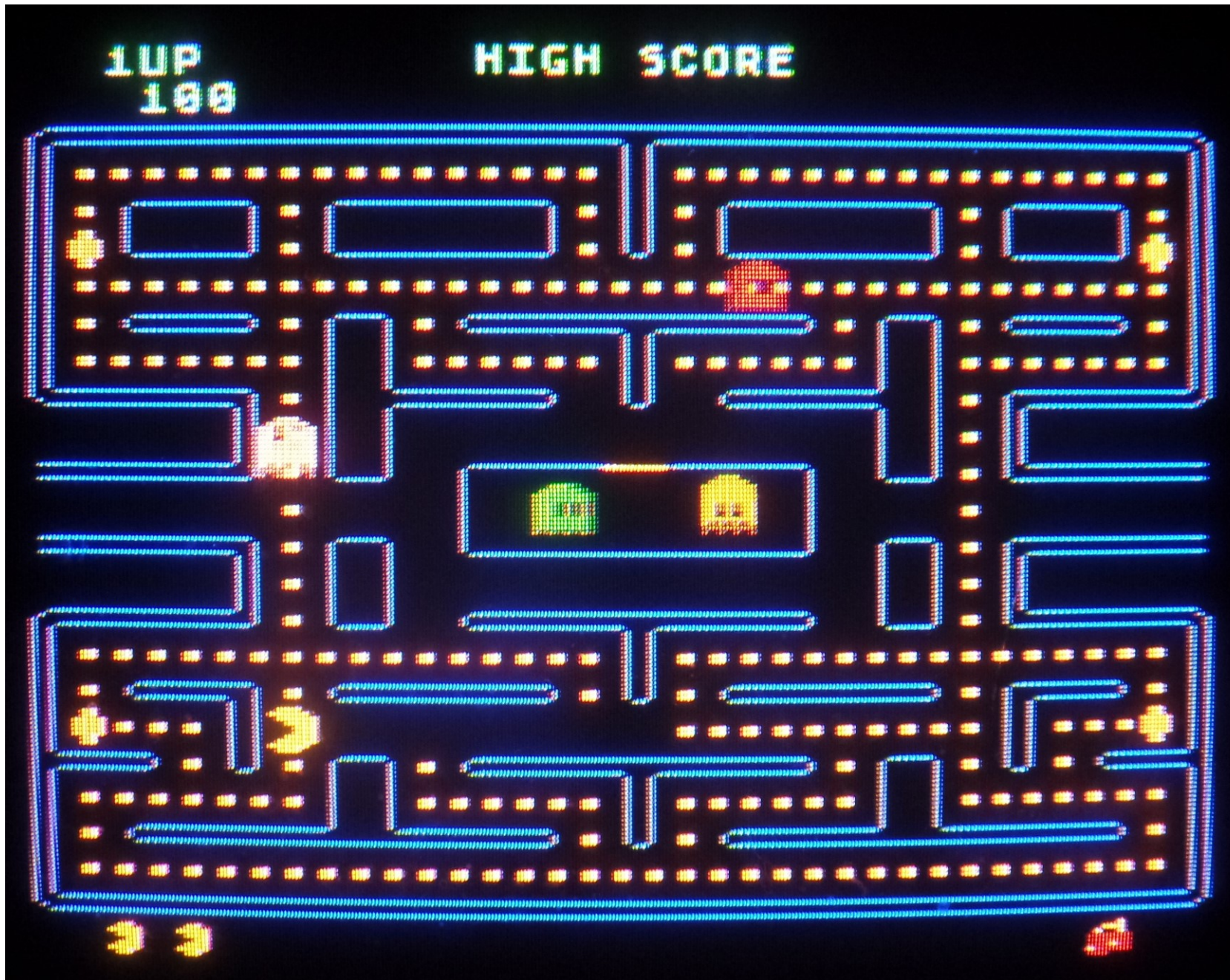
Sample Character	"A"	Chevron	Duck
Bit maps	00000000 00011000 00111100 01100110 01100110 01111110 01100110 01100110	00011011 11000110 10110001 01101100 01101100 10110001 11000110 00011011	00000000 00000000 00100000 11010000 00100001 01111111 01111110 00000110
ANTIC Mode:	— 4cc	4cc	4cc

Modes 2 & 3 for productivity
Modes 4 & 5 for complex games

Star Raiders: best original game



Atari management liked this game so much that they required a simple keyboard on the Atari 400



Porting
Arcade
Games was
easy on the
Atari PCS
machines:
Pac Man



Donkey Kong



Space Invaders



Galaxian

For a personal computer

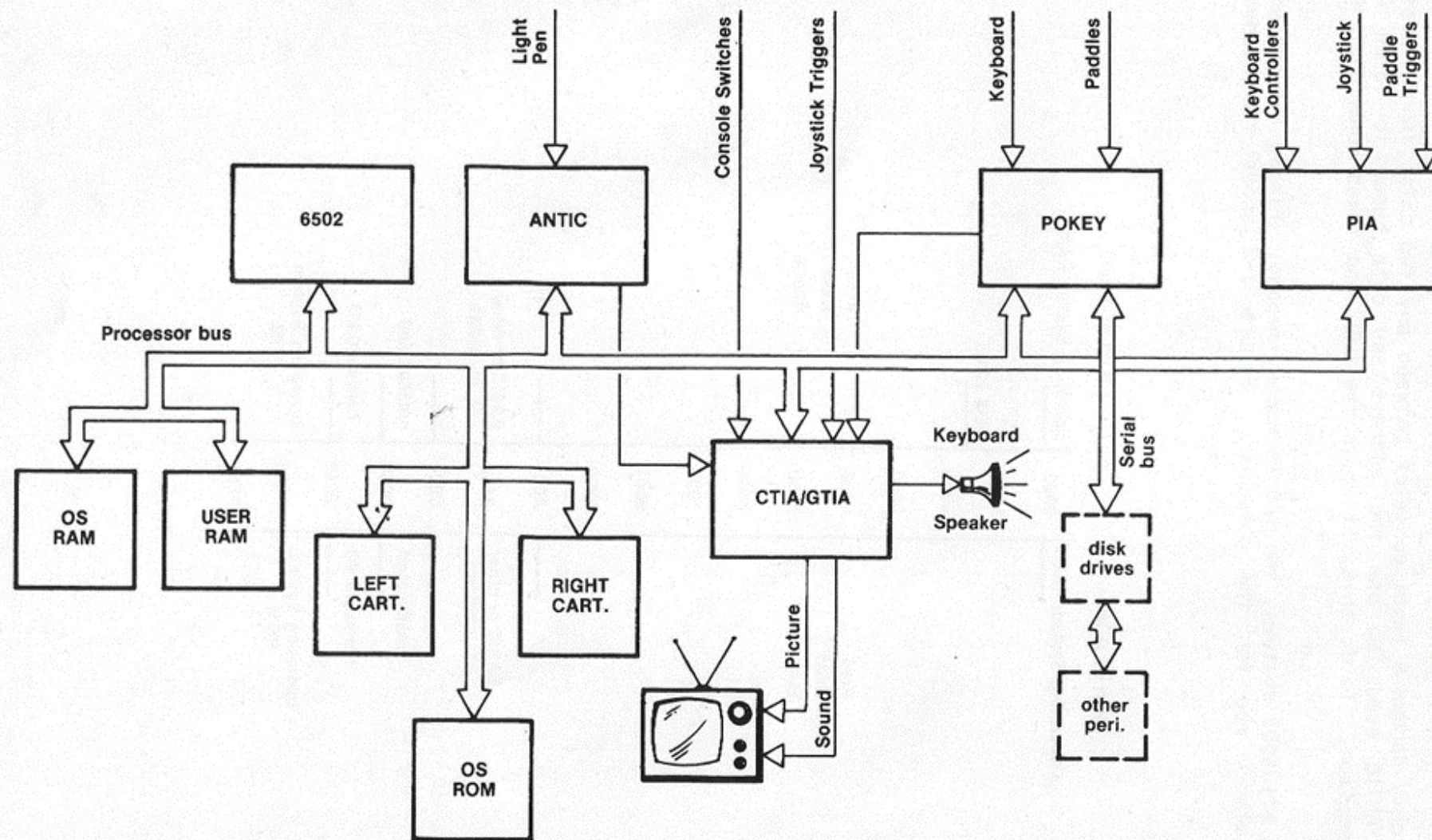
- Support personal productivity applications! (next slide)
- Provide character display
 - TVs limited us to 40 characters/line
- Provide a keyboard – text entry, and complex game control
- Provide for peripheral expansion for: printers, mass storage and communications (e.g. dial up modems)
- We wanted slots (like the Apple II and S-100 machines)
 - but FCC rules would prevent that
- Necessity: design a serial bus (SIO)
 - Direct ancestor to USB

Personal Productivity Applications

- **word processing** – replace typewriters
- **calculate** – since they were called computers; spreadsheets were not invented yet, but Visicalc was ported to it quickly
- **communicate** – at that time: to bulletin boards and for character-oriented email
- **manage files** – although computer storage at the time was small
- **educate children**
- **BASIC programming** – for interested end-users
- **advanced programming** – for software developers who would support and extend the system - assembly, C, etc

Hardware implementation

- Same 6502 as Atari 2600, 50% faster (1.8MHz)
- Original design: 4KB DRAM; first shipments: 8KB DRAM
 - Atari 800 expandable to 48KB by end customers
- Sorted IO into 3 custom ASICs and 1 standard part:
 - ANTIC: for managing direct memory access (DMA), moving video data, the display list processor and DRAM refresh
 - CTIA/GTIA: collecting and displaying video data
 - POKEY: non-video IO, including potentiometers, keyboard scanning, audio and serial bus data
 - PIO (6520): 4 bits of joystick input on each of 4 controller ports



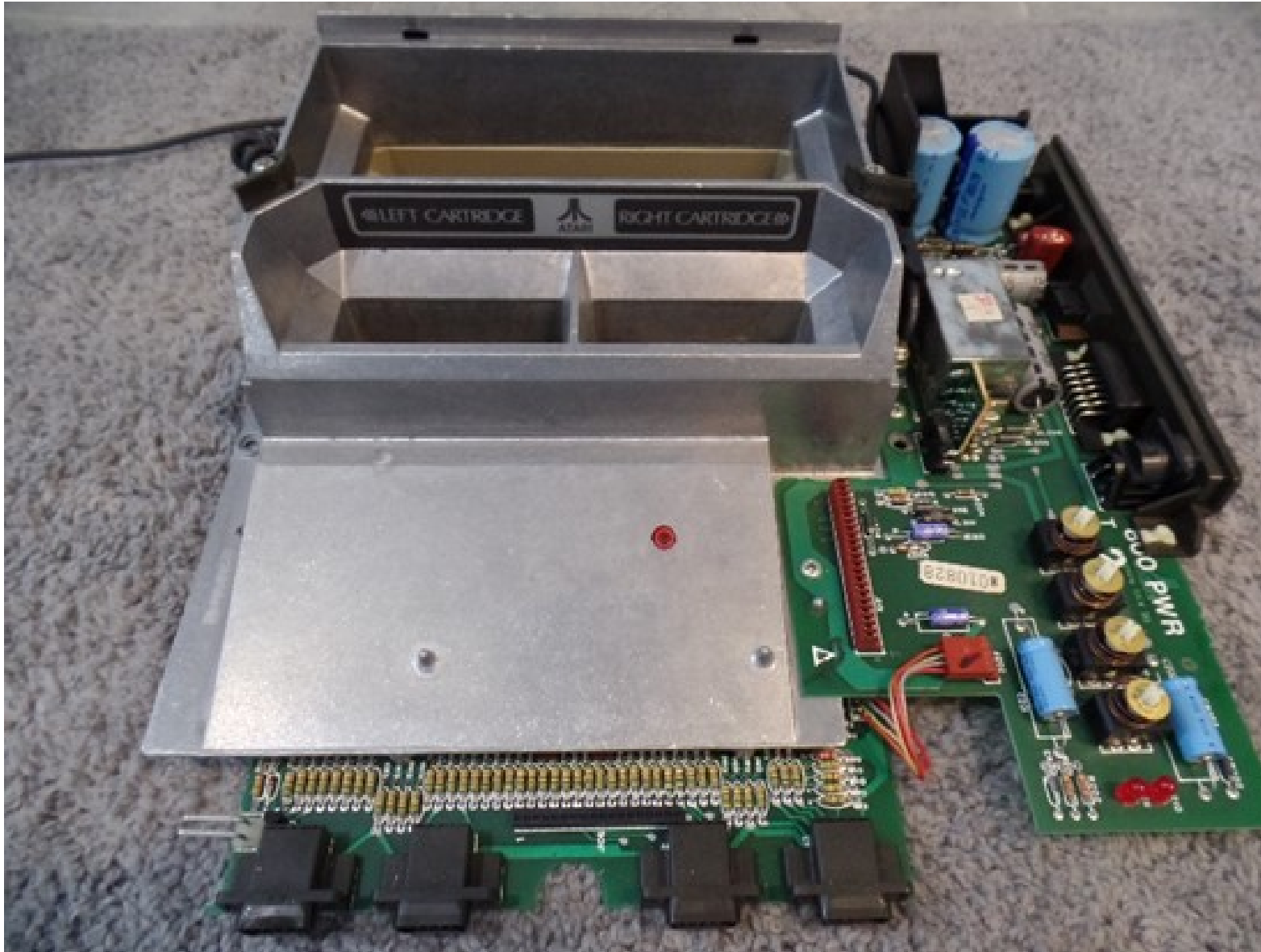
ATARI 400/800

System Software

- Basic Input Output System (BIOS)
 - IO Control Block programming interfaces to manage IO devices
 - It included firmware to manage Serial IO (SIO) device
 - 8KB ROM + 2KB floating point utilities
- BASIC interpreter
 - Atari BASIC bundled with the machine
 - Microsoft BASIC sold as a an option
- Disk Operating System
 - The BIOS will search for it, and load it if present on a diskette

BIOS managed IO devices

symbol	function	location	IO Control Block operations
E:	Editor	internal	Read (K:) and Write (S:)
S:	Screen	internal	Write
K:	Keyboard	internal	Read
P:	Printer	Via SIO	Write
C:	Cassette	Via SIO	File Read and write
D:	Disk	Via SIO	File Read and write
R:	RS-232 Serial	Via SIO & 850	Stream Read and write



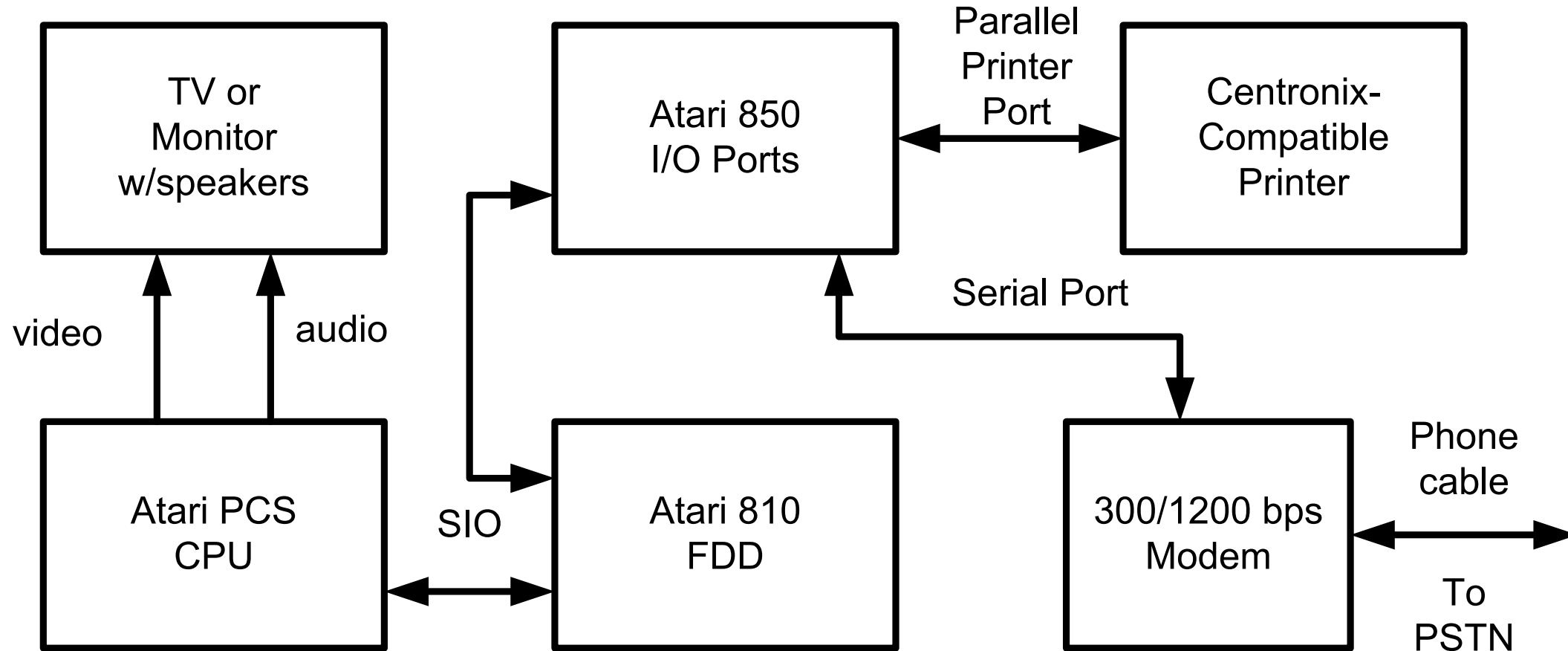
**Atari 800
inside view,
with 2mm
aluminum
casting.**

**FCC limit:
-60dBm/MHz
= 1 microwatt
per MHz**

Atari 800 computer w/peripherals



Complete Atari system diagram: 800 CPU, 810 Diskette Drive, 850 I/O ports



Lessons learned, and not learned

- As a game console:
 - We provided good self-development tools to attract developers
 - The founders of Activision and Imagic had not left yet, so Atari was not afraid of third-party developers – that happened later
- As a computer:
 - Massive cost reduction possible after FCC changed the rules
 - e.g. 600XL, 800XL
 - The Commodore C64 passed Atari in the market w/lower price
 - Atari should have shipped a unit with integrated FDD (1450XL)
 - The Apple II and Apple III began integrating FDD
 - The Amiga computers all had an integrated FDD
 - Atari could build an expansion unit with hardware slots (1090)

Atari 800XL, cost reduction

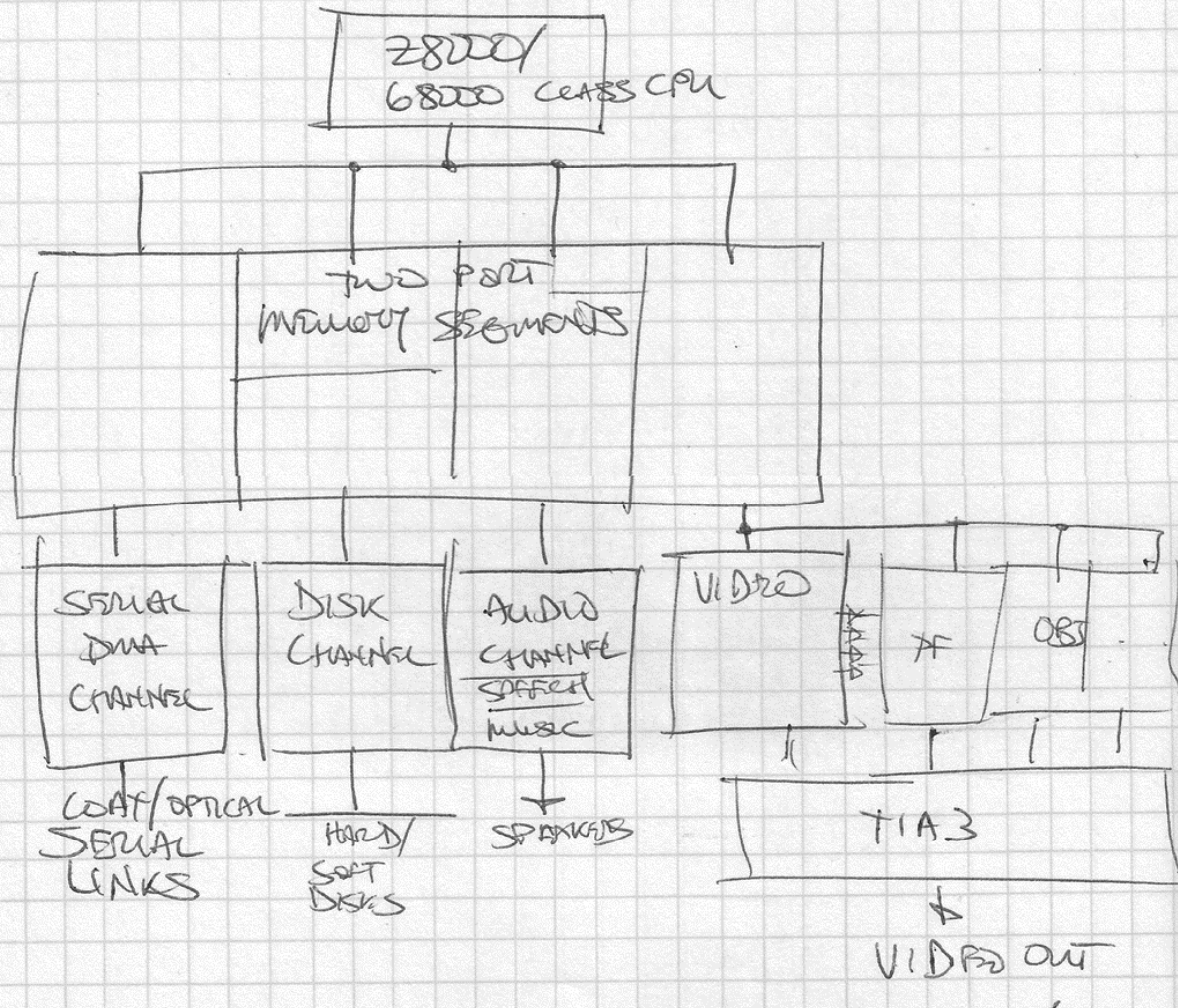


New FCC limit:
-43 dBm/MHz

Other simplifications:

- 1 cartridge slot
 - 2 controller ports
 - Concealed PBI port
- PBI = Peripheral Bus Interface

PROPOSAL FOR 'STOPS OUT' HIGH POWER ENTERTAINMENT COMPUTER



Last day at Atari:
Proposal for a
'stops out next
generation
machine

3 years later, in
1982, we started
design work on the
Amiga. This
shipped in 1985, 6
years later.

Retro Machine Futures and applications

Software emulation
New hardware development
Communication applications

Atari 800 “8bit” software emulation

- <https://atari800.github.io/>
- <https://sourceforge.net/projects/atari800/>
- <http://www.emulators.com/xformer.htm>

Modern Atari 8-bit Computer peripherals

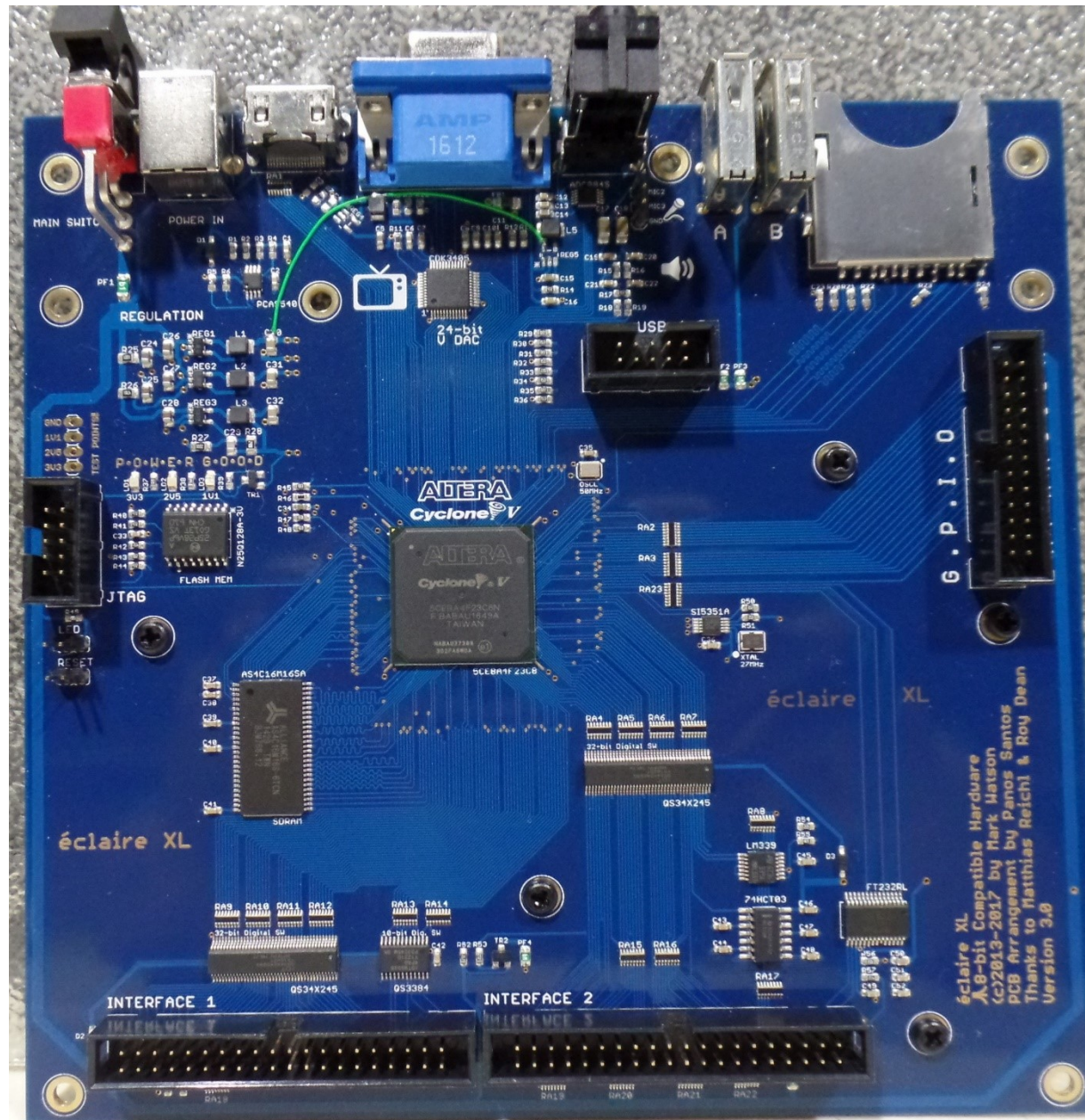
- Lotharek ships an SIO2SD, which maps SD memory devices to SIO for mass storage
- AtariMax makes Atari Peripheral Emulators (APE)
 - The first APE connect to a PC serial port
 - The new APE connect to a USB port
 - APE emulate:
 - Mass storage: the PC looks like several disk drives
 - Printers, mapping through the PC operating system device drivers
 - Communication, including internet access



Modern Atari computer hardware

- Two directions: FPGA and original chips
 - FPGA = Field Programmable Gate Arrays
 - See also Flashback 2.0, Amiga 500 MIST
- Eclair 3.0 - FPGA
 - Mark Watson and Panos Santos have prototyped and shipped a small number of FPGA-based Atari 800 XL implementations
 - <http://www.64kib.com/Atari%20800%20FPGA%20Manual.pdf>
- AtariAge XEL 1088, with original silicon
 - Alternative Motherboard project

<http://atariage.com/forums/topic/272817-1088xel-atari-itx-motherboard-diy-builders-thread/>

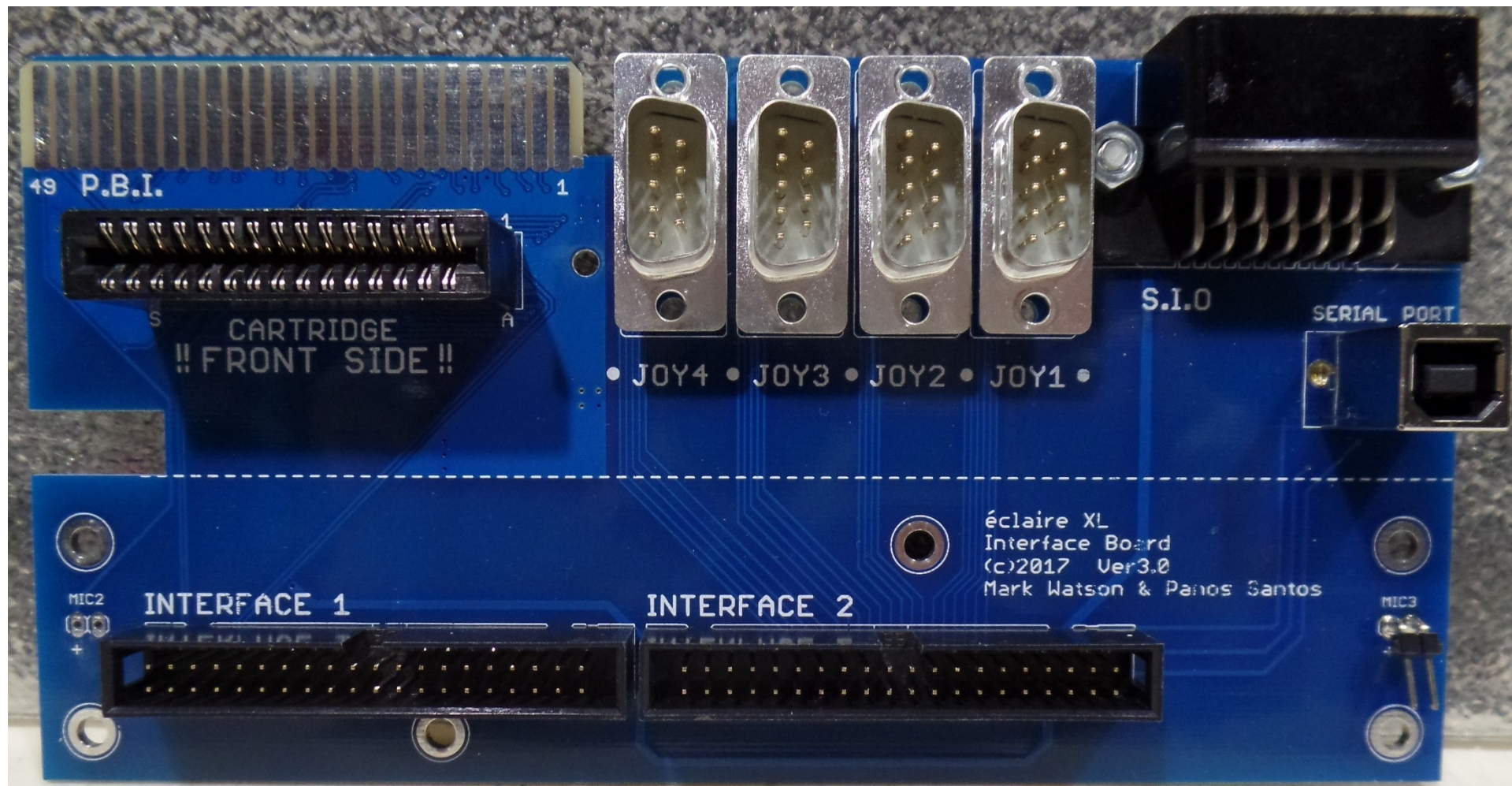


Eclaire XL main PCB

Differences:

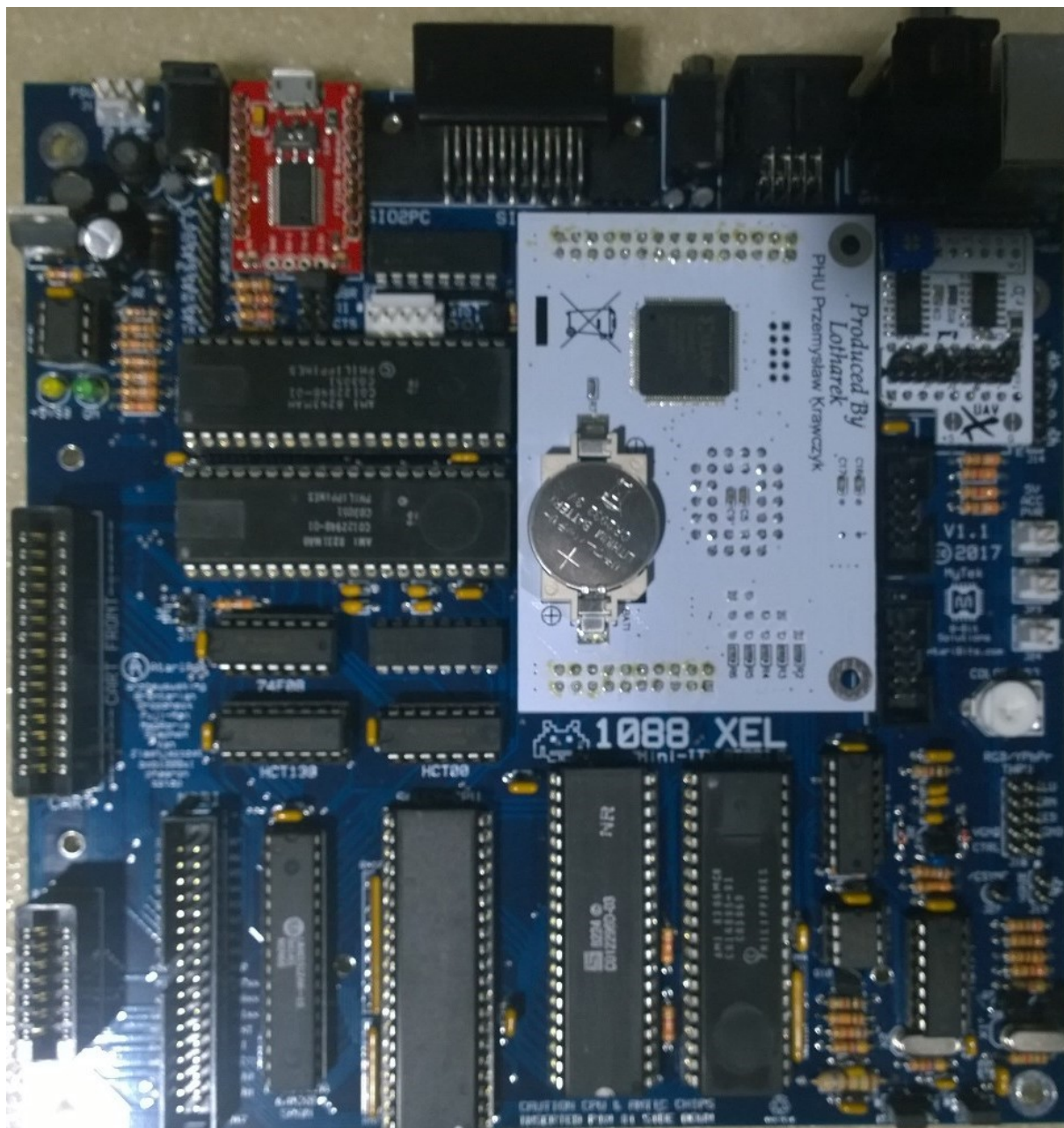
- VGA video output
- SD card mass storage
- USB for keyboard
- Lots of RAM

Eclaire XL IO board



Eclaire XL FPGA resources

- Mark Watson has been posting design files on <http://www.64kib.com/redmine>
- Photos: <http://atariage.com/forums/topic/263044-developerstesting-required-for-mini-itx-clone-system-eclairerxl/>
- Nir Dary's demonstration video: <https://www.youtube.com/watch?v=ordWyp8HZZ8&t=626s>

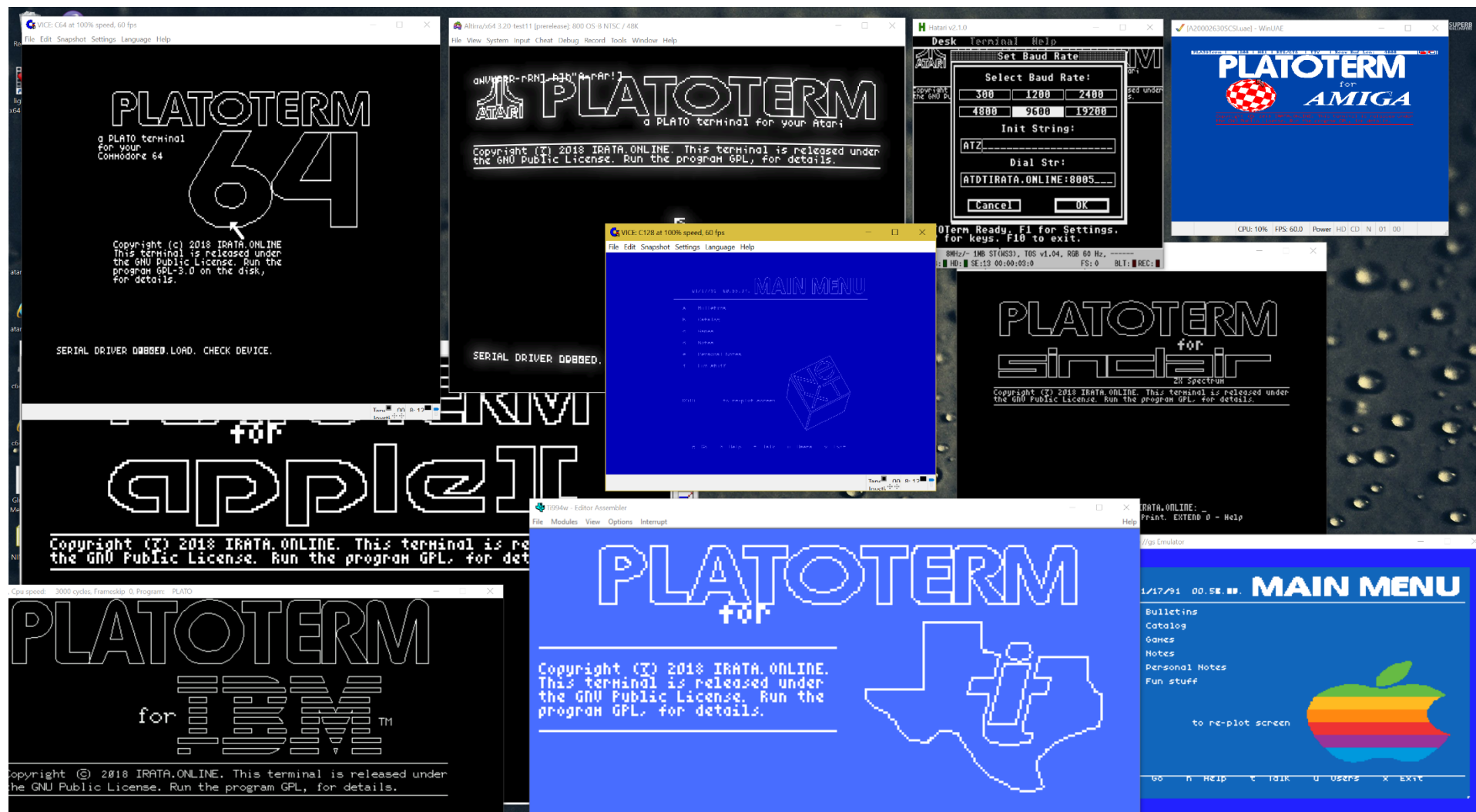


XEL 1088

- original silicon
- dual POKEY audio
- IBM IO for mouse & keyboard
- video: RGB & composite
- PBI port
- cartridge port

Modern computer applications

- Most of the vintage computers were designed with computing resources far inferior to current common PCs or mobile phones
 - iPhone X has a hex-core ARM
 - Intel CORE i7 is a quad core beast
 - Lots of video display resolution
 - Lots of communication bandwidth
- Thomas Cherryhomes has designed a cross-platform communications application: PlatoTerm
 - See illustration on next slide
 - Note: it will also work on browsers



C64, Atari 8-bit, Atari ST, Amiga, Apple II, NeXT, Sinclair, IBM PC, TI 99/4, Apple MAC and web browsers

Resources

Design Credits (partial)

Learn more

Contacts



Partial Design Credits

- Project leader: Jay Miner
- Prototyped video: Ron Milner
- Hardware: Joe Decuir (system, ANTIC); George McLeod (CTIA/GTIA); Doug Neubauer (POKEY, Star Raiders)
- BIOS Software: Al Miller, Dave Crane, Larry Kaplan, Bob Whitehead & Howard Bornstein
- Atari DOS: Bill Wilkinson (OSS)
- Atari BASIC: Paul Laughton & Kathleen O'Brien
- SIO & Atari 850 design: Scott Schieman et al
- Industrial design: Doug Hardy (400); Kevin McKinsey (800)

To learn more

- **ANTIC Podcast:** <http://ataripodcast.libsyn.com/>
- **Atari Museum:** <http://www.atarimuseum.com/>
- **Atari 8-bit computers:** https://en.wikipedia.org/wiki/Atari_8-bit_family
- **Racing the Beam:** MIT Press, Platform Series book on the Atari VCS (2600).
- **Breakout,** How Atari 8-bit Computers Defined a Generation, Jamie Lendino
- **Atari: Business is Fun,** Goldberg & Vendel, definitive *social* history of Atari.
- **De Re Atari,** Chris Crawford, program Atari 8-bit PCs
- **“Game On!”** about the Atari 2600 design, IEEE CES Magazine, July 2015
- **Encore: Atari’s Second System,** IEEE CES Magazine article, Jan 2016
- **The Amiga: a Hardware Engineering Story,** IEEE CES magazine, Oct 2016
- **Design Case History: the Atari Video Computer System,** IEEE Spectrum, March 1983

Contact information

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Questions?



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